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Specification and Drawings, as originally filed, with Application for Patent Serial No: **2,375,870**, on March 11, 2002, by **HER MAJESTY THE QUEEN IN RIGHT OF CANADA AS REPRESENTED BY THE MINISTER OF AGRICULTURE AND AGRI-FOOD CANADA AND JAMES M. SUTTIE (CO-APPLICANT, CO-INVENTOR)**, for "Method for the Evaluation of Velvet Antler". The said invention was made while Allan L. Schaefer, Richard A. Lawrence, Garry B. Des Roches and Pierre LePage were employed as public servants, as defined in the Public Servants Inventions Act in the Department of Agriculture and Agri-Food Canada, pursuant to Section 3 of that Act, the said invention has been determined to be vested in **Her Majesty The Queen In Right Of Canada As Represented By The Minister Of Agriculture and Agri-Food Canada.**

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ABSTRACT

A method for evaluating the internal composition of a velvet antler involving the steps of: (a) obtaining at least one infrared thermographic image of said velvet antler, from at least one view, wherein said obtained thermographic image is capable of being represented as an array of pixels providing temperature data representative of temperature information at the corresponding part of the image; (b) calculating the value of at least one statistical measure of the temperature data for each thermographic image; (c) providing a predictive model wherein said internal composition characteristic is included as an output variable, and the at least one statistical measure of temperature data for each thermographic image are included as input variables; and (d) solving said predictive model to provide a measure of a velvet antler internal composition characteristic. The internal composition characteristics of interest include measures of antler maturity such as degree of calcification, predicted ash content, and measures indicative of metabolic activity. Additionally, the invention provides a method for using the at least one statistical measure of the temperature data to generate a map of each antler scanned that indicates areas of statistically higher and lower temperatures than an antler mean temperature range established for the species scanned. Further, the areas of said map identified as low temperature can be further identified as areas likely to have internal compositions with low metabolic activity, and potentially high calcification. The method of the invention is useful for evaluating velvet antlers grown on a variety of animals. Method variations are provided that enable evaluation of velvet antler both *in vivo*, and *in vitro*. Velvet antler may be evaluated *in vitro* in cooling after removal from the animal, and in warming from a frozen state.

"Method for the Evaluation of Velvet Antler"

FIELD OF THE INVENTION

The invention relates to the methods for evaluating the internal composition of velvet antler.

BACKGROUND OF THE INVENTION

Velvet antler refers to a unique regenerating tissue growing from the cranial pedicle predominantly from deer species. This tissue is composed of a variety of mineral, lipid, protein and endocrine factors (Suttie et al, 1998), and prior to maturation displays a very high growth or cell proliferation rate.

The utilization of deer co-products such as velvet antler is a valued part of Chinese traditional medicine dating back about 2000 years, (Shuazhi, 1993 and Issacs, 1993). More recently, the unique composition and endocrine factors have been factually demonstrated in velvet antler (Suttie *et al.*, 1998) and attention has been focused on understanding the effect of anatomical antler sites (Sunwoo *et al.*, 1995; 1997) as well as period of growth (Suttie *et al.*, 1989; Han and Jhon, 1994) on antler composition. Canadian and United States Patents have issued that identify biological properties of velvet antler such as a novel antler-based growth factor, (Canadian Patent 2,132,219 to Arnett *et al.*), a process for purifying antler derived bone growth factors, (US Patent 5,408,041 to Mundy *et al.*), and a biogenic preparation from ossified deer antlers, (Canadian Patent 2,201,768 to Vladimorovich).

Subjective grading or classification standards have been suggested and utilized based on the recognition that velvet antler composition, measured by factors such as ash content, will vary depending on the stage of maturity, size and weight (Stagline, 1993). As such, the evaluation or pricing standards for velvet antler related to these subjective classifications and morphological measurement standards are typically applied. In general, there is agreement that the overall quality of the velvet antler is inversely proportional to its ash content, and that ash content is related to the stage of antler growth.

Velvet antler is unique in that it regenerates growth and nerve tissue every year. This growth rate and regeneration is indicative of unique growth factors and biological properties within the antler which are desirable in many forms of medical treatment around the world. Velvet antler grows exponentially from casting of the previous hard antler to the cessation of growth some 100 - 110 days later. Growth of the antler takes place at the tip, in contrast to the horns of Bovidae which elongate from the base. During growth of velvet antler the least

differentiated and least calcified tissue is immediately proximal to the tip. Further from the tip the velvet antler cartilage progressively calcifies and this calcification becomes organized into true bone. As velvet antler growth begins to slow at the end of growth, the band of bone formation gradually advances until the whole antler is composed of bone. When the antler is fully calcified, the soft furry velvet skin peels off to reveal the hard, sharp bone. The ash content of the antler is used as a measure of the amount of calcification present in the velvet antler.

Deer velvet antler is removed from the animal once each year and is typically processed by drying before export to market. The time of removal is judged by the producer to maximize velvet antler size, (and hence monetary value), and minimize the degree of calcification, (ash or mineral content). The producer is guided by industry set grades and price indicators. However, there is currently no way of accurately assessing ash content when the antler is still growing and no way of indirectly measuring ash content in the processed antler, after removal.

An objective classification process which more accurately reflects composition has been wanting. Commercial operators need accurate information to enable them to judge the 'best' time to harvest, (remove), the velvet antler. The concept of 'best' time can be client specific, but generally should maximize the weight of the antler while minimizing calcification. This is because the calcified portion of deer velvet is unlikely to confer any human health benefit. Growth and regrowth cycles vary between animal breeds and temperate zones. The male Elk in North America regrows its antlers annually, such that antlers can be harvested every year after the animal has reached a specified age. In the prime growing phase, velvet antler can grow up to 0.5 kg per day and calcification is very rapid once the antler meets maturity – days can make a difference to the ash content. Thus, monitoring to assess optimum harvest time would be very advantageous to ensure harvest before calcification can proceed beyond a point that impacts the antler value. Although there are grading specifications based on dimensions, there is such variability among stags that this grading system is useful only for coarse grouping of similar products to facilitate sale. It would be a major advance if a producer could grade the velvet antler accurately and use this information to accurately measure optimum time of removal. In fact, an objective system may soon be demanded by the velvet antler industry. For example, market reports from Korea

have suggested the adoption of a product composition validation based on ash content. Also, the evolution of global standard operating procedures for food products in general may necessitate a greater element of objectivity in product classification.

Further, when a processor/purchaser evaluates velvet antlers they are typically faced with a room full of antlers which are in a frozen state. Current practice is to perform a subjective evaluation of the antlers to estimate antler maturity and/or ash content. It would be to the advantage of both the purchaser and the producer to have an objective method of evaluating velvet antler, in a whole state, for maturity and/or ash content.

Previous research in the area of velvet antlers has demonstrated that the analytical procedure's of axial tomography and angiography can be used successfully to determine density gradients in velvet antler, (Suttie and Fennessy, 1990). However, these tests are usually conducted on sacrificed animals or harvested antler sections. At best, these techniques require the use of an anethestised animal and complicated procedures using radiopaque dyes, invasive catheterization and film developing.

Clearly, there is a need for a non-invasive, nondestructive method for velvet antler evaluation and classification both *in vivo* and *in vitro*.

Infrared thermography (IRT) is a non-invasive technique used for monitoring infrared radiation from objects. Infrared thermography has also been used by one of the co-inventors to successfully detect stress states and meat quality in domestic animals (Jones *et al.*, 1995, Tong *et al.*, 1997), tissue composition in domestic animals (Schaefer and Tong, 1998) and inflammation such as mastitis in domestic animals (Schaefer *et al.*, WO 00/57163, 2000). However, previous research and invention were insufficient to teach any application of infrared thermography for determining compositional or maturation characteristics in a unique, regenerating tissue like velvet antler.

SUMMARY OF THE INVENTION

In the present application, infrared thermography is demonstrated to display utility both *in vivo* and *in vitro* in the diagnosis of velvet antler maturity and composition. The inventors recognized that it would be of considerable value to develop a system which assessed ash content while the antler was still growing. This allows the producer to harvest velvet antler to precise specifications and the processor of the velvet antler to know exactly

how to trim the dried velvet antler to fulfill the market requirements. A system such as this has advantages over a system which assesses velvet antler after it was removed, as it provides more information.

The inventors discovered that, surprisingly, the infrared thermographic expression of an antler in the velvet or immature stage of growth is correlated with the degree of maturation, verified by the extent of inorganic mineral or ash content. The inventors also discovered that this relationship is apparent whether the scan is taken on the live antler (*in vivo*) or on a harvested antler section (*in vitro*) in rewarming or cooling.

The inventors discovered that there is both significant within antler and across antler variation in infrared thermographic temperature for antlers scanned *in vivo*. Also evident is the discovery that an *in vitro* antler also displays this variation when it is evaluated in the period immediately subsequent to harvest, while it is cooling to room temperature, and when it is evaluated while warming from a frozen state. Interestingly, and a discovery that has not been reported previously in the scientific or patent literature, was the evidence that infrared thermographs of either a live, cooling and/or warming antler show data that corresponded to the ash content of the scanned velvet antler. In other words, the ash content of the antler section, a commercially relevant measure, is predictable from an infrared thermograph. Other internal composition characteristics such as lipid, amino acid or endocrine values, can also be predicted from such analysis since it is known that antler sections that vary in ash content also vary in other compounds (Sunwoo *et al.*, 1995).

Some breeds, such as Elk, are very averse to capture. Thus, direct physical tests to assess antler growth and/or maturity are difficult. The non-invasive infrared thermography method provides producers with a method of monitoring antler maturity without the need for capture of the animal. Preferably the infrared thermography method of this invention is used in a manner that does not cause undue stress to the animal.

Angiographic studies of velvet antler growth (Suttie and Fennessy, 1990) have demonstrated that vascularization is apparent and extensive in growing antler. It is also known that the extent of vascularization in a tissue usually reflects the metabolic demands or activity in the tissue (Schaefer *et al.*, 1982). In velvet antler, a young regenerating section will display a greater degree of vascularization than a mature or so called calcified or "hardened off" section.

Without being limited to such, the inventors surmise that their method using infrared thermography works to detect the internal composition characteristics of live velvet antler due to the unique circulation system in antlers. Without limitation, the inventors believe that infrared thermographic analysis produces results indicative of the internal composition of velvet antler *in vivo* because areas of blood flow and areas of metabolic activity within the velvet antler tend to generate more heat than areas that are calcified. Biological events tend to have huge inefficiencies, so it was surmised that antler areas with high levels of metabolic activity, or low levels of calcification, would tend to give off higher levels of heat. Additionally, blood flow to a tissue is one of the factors that can influence the intensity of an infrared thermographic scan, (Clark and Cena, 1972). Areas of the antler that are calcified tend to have lower metabolic activity, and lower, or constricted, blood flow, and thus it might be surmised that they would give off lower levels of heat. The inventors have discovered that infrared thermography can be used to detect these differences in heat levels in a meaningful way that can be correlated to the ash content, or level of calcification, of the antler.

Further, and without limitation, the inventors believe that infrared thermography is useful in the assessment of velvet antler *in vitro* in part because the different material compositions within the velvet antler have different densities and different heat capacities. As such, the inventors surmise that the different compositions within the velvet antler warm and cool at different rates. The inventors discovered that this differential in rate of cooling and warming is measurable using infrared thermography in a meaningful way, and surprisingly, it can be correlated to the internal ash content of the measured velvet antler.

In making the present invention the inventors scanned 26 wapiti or elk, (Cervis elaphus), stags and captured images of their antlers. The stags were scanned, using known infrared thermography equipment, during the rapid antler growth phase. Dorsal scans were collected from the animals that had been brought into a handling area. Care was taken not to unduly stress the animals. Following capture and *in vivo* image collection the velvet antlers were removed from the animals using conventional industry procedures.

The harvested antlers were then frozen to -20°C. In order to examine differential heating characteristics, these antlers were scanned, using the same equipment, while rethawing. Antlers were rethawed at 20°C for 5 hours. Infrared thermography images were again captured at 0 hour, 2.45 hours and 5 hours post removal from the freezer. The antlers

were thawed in a room held at a constant temperature of 20°C and with a circulating fan directed at the antlers in order to ensure a uniform temperature condition surrounding the antlers.

Representative samples from these antlers were subsequently analyzed for ash content using established laboratory procedures. One antler section included in the present compositional analysis data was from a mature antler set and another was from an immature antler set.

Since materials of different density and heat capacities are known to heat or cool at different rates it was speculated that antler tissue differing in density or ash composition would also display differential infrared thermographic heat characteristics *in vitro*. The differential rate of antler section thawing was recorded. The thermographic scan changes were seen to display different rates (slope) of heating suggesting that the assessment or classification of the antler could also be conducted on thawing, or cooling, antler tissue *in vitro*.

A later study was also performed by the inventors wherein antlers were scanned using infrared thermography in the same manner of the study described above. However, after removal, the velvet antlers were analyzed with infrared thermography in the first hour after removal from the animals to obtain a measure of the differential rate of antler cooling. Subsequent analysis has convinced the inventors that infrared thermography can be used in the period just after removal to determine the degree of calcification of the velvet antler, as well as other internal composition features.

Further, the inventors have been able to show the use of infrared thermography to determine which velvet antlers amongst a group are likely to exhibit higher ash content. The inventors have also established that infrared thermography can be used to map areas of higher and/or lower metabolic activity, and therefore higher/lower degree of calcification, within the antler for use as a trimming tool for the processor. The areas of high calcification can be assessed and compared to overall antler area to predict the percent ash content and/or assign the antler a grade rating.

Broadly the invention provides a method for evaluating the internal composition of a velvet antler, comprising the steps of:

obtaining at least one infrared thermographic image of said velvet antler, from at least

one view, wherein said obtained thermographic image is capable of being represented as an array of pixels providing temperature data representative of temperature information at the corresponding part of the image;

calculating the value of at least one statistical measure of the temperature data for each thermographic image;

providing a predictive model wherein said internal composition characteristic is included as an output variable, and said at least one statistical measure of temperature data for each thermographic image are included as input variables; and

solving said predictive model to provide a measure of said velvet antler internal composition characteristic.

The method can be further defined wherein the predictive model output variable is used to generate a map of each antler scanned that indicates areas containing predicted levels of the internal composition characteristic of interest. Alternatively, the at least one statistical measure of the temperature data is used to generate a map of each antler scanned that indicates areas of statistically higher and lower temperatures than an antler mean temperature range established for the species scanned. Further, the areas of said map identified as low temperature can be further identified as areas likely to have internal compositions with low metabolic activity, and potentially high calcification.

The method can further comprise the step of obtaining the value of at least one property of the velvet antler, *in vivo* or *in vitro*, that does not provide temperature information, and wherein the property is included as an input variable in the predictive model. The property that does not provide temperature information can be a geometric measure of the antler, a variable relevant to the animal from which the antler was removed, such as, without limitation, animal weight, age, a factor accounting for species type, or any other variable known to impact on antler growth.

The method can further comprise the steps of using said predictive model to solve the physical volume of said areas of low temperature, solve the physical volume of said antler, and calculate the percentage by volume of the antler with the low temperature indication. Then the percentage by volume value can be used to determine expected ash composition of the velvet antler.

The expected ash composition can then be compared with a predetermined maximum

ash composition, to determine the optimum harvest date of the velvet antler.

The method can be adjusted such that the at least one infrared thermographic image is taken of one or more antlers *in vitro*, from one or more views, within a reasonable period after the antler is removed from the animal. The method can then further comprise the steps of:

taking at least one infrared thermographic image of the antler from the same view(s), at a time period statistically later than the first image;

analyzing the images to calculating a measure of temperature changes at points within the antler; and

using said temperature change data to predict areas of high calcification and low metabolic activity.

The method can also be adjusted wherein:

the at least one infrared thermographic image is taken of one or more antlers *in vitro*, after the antlers are frozen;

a second image is taken after the antler has been allowed to warm for a statistically significant time period;

the images are analyzed to calculate data indicating temperature change at points within the antler;

inputting the temperature change data into a predictive model; and

solving said predictive model to find areas of high ash/ low metabolic activity.

Broadly, the invention also provides an apparatus for determining an internal composition characteristic of a velvet antler, comprising image acquisition means, computing and storage means, and output means to perform the method of this invention.

The present invention has application to a wide range of velvet antler producing species. Specifically, the term "animal" is meant to include, without limitation, species in the cervidae (deer) family, (cervus elaphus manitobensis, cervus elaphus nelsoni, cervus elaphus roosovelti, cervus elaphus scoticus, cervus elaphus xanthopygus, cervus sika, and cervus unicolor), and alces alces, rangifer tarandus, dama dama, odocoileus virginianus, and rusa timorensis. Common names for some of the animals included are red deer, moose, antelope, caribou, reindeer, and elk.

As used herein and in the claims the term "velvet antler" is meant to mean immature antler in its growing stage, before complete calcification of the antler to bone, and including

the velvet skin. The term "*in vivo*" is meant to mean live, on the animal, and "*in vitro*" is meant to mean removed from the animal.

The inventors' system further enables a producer to use an infrared camera to accurately determine the degree of mineralization in the growing velvet and thereby cut accurately to any specification set by a prospective purchaser. This information can then be passed to the processor who can use the knowledge to break down the antler, (sometimes referred to as 'stick'), in the best possible way to maximize returns from different parts of the velvet.

The tips of the tines and upper parts of the antler are typically where active growth takes place, and thus they are the portions of the velvet antler used for high value products, from a commercial standpoint. The use of the infrared temperature detection method of this application can be used to delineate these high value areas and aid the efficient trimming of the velvet to allocate the high value portions to appropriate markets. This can be done by relating temperature bands to levels of calcification in a map form which can then be used to accurately set out where to cut the velvet stick after processing.

The infrared thermography method can further be used as a culling tool to identify animals which produce the most antler with the highest quality. Such animals can then be identified and selected for breeding purposes.

In one embodiment of the invention the producer can scan the animals frequently to determine the best cutting time using software and infrared imaging equipment, wherein the computer software provides ash content data as an output variable. In a further embodiment, the computer software provides the actual cutting decision for the farmer, for example when a particular pattern is detected, a flag on the screen indicates to the farmer/producer that the animal is ready for a particular specification.

In an alternate scenario, the processors provide infrared cameras to the farmers which are programmed with software which informs the farmer when the velvet has the desired specifications for the processors desired application. An image representative of the infrared reading which is indicative of the ash content then accompanies the velvet antler to the processor.

The information from infrared thermographs can be used to develop the prediction models to estimate velvet antler internal composition characteristics, and to further indicate

the degree of maturity of either *in vivo* or *in vitro* antler tissue. Such predictive models can be developed for specific deer species using representative sample populations of animals and selection criteria can be developed for specific market demands.

The sample population of velvet antlers, (or animals with velvet antlers), used to develop a predictive model is preferably from a group of animals of the same species, the group containing a sufficient number of antlers/animals that a statistically significant relationship or correlation between one or more of the selected input variables and the antler internal composition characteristic (output variable) of interest can be determined. The sample population may contain as few as three antlers/animals, and more preferably greater than ten antlers/animals, and still more preferably, greater than 100 antlers/animals.

The infrared thermographic images of the antlers can be obtained using standard. commercially available infrared thermographic cameras, equipment and related computer software. The term "infrared thermographic image" as used herein and in the claims, is meant to include a scan output in the form of either or both of a visual image and corresponding temperature data. The output from infrared cameras used for infrared thermography typically provides an image comprising a plurality of pixel data points, each pixel providing a temperature data point which can be further processed by computer software to generate for example, mean temperature for the image, or for a discrete area of the image, by averaging the data points over the number of pixels.

Once infrared thermographic images are obtained for each antler in the sample population from the selected views, values for selected statistical measures are calculated for the temperature data, to provide a set of data for each of the input variables.

Preferred statistical measures of the temperature data include measures of central tendency, measures of dispersion, and measures of total temperature. The term "measure of central tendency" as used herein and in the claims is a statistical measure of a point near the centre of a group of data points. Without limitation, the term includes the mean, median and mode. The term "measure of dispersion" as used herein and in the claims is meant to include statistical measures of spread from the measure of central tendency for the group, and include without limitation, variance, standard deviation and coefficient of variation. Definitions of these statistical terms may be found in standard statistic texts, one such text being Steel and Torrie (1980), which definitions are incorporated herein by reference. As used herein and in

the claims, "total temperature" is the mean temperature of an infrared thermographic image × image area expressed in number of pixels (e.g. if mean temperature = 20°C and the image area = 200 pixels, then total temperature = 20°C × 200 = 4000°C).

The selection of other, non temperature input variables may include properties that are obtained independently of the infrared thermographic images. Such variables include, without limitation, animal weight, animal age and species type, time of year, animal genetics in the case of hybrids, and antler anatomy such as length, width or circumference at specific sites.

The actual value for the antler internal composition characteristic of interest is measured for each antler in the sample population to provide a set of data for the output variable. The method used to measure the values for the output variable for the antlers in the sample population will depend on the nature of the selected internal composition characteristic. For instance, where the output variable is ash content, the actual ash content may be determined according to known or accepted methods.

Using the data obtained for each of the input variables and the data obtained for the output variable, a relationship between the input variables and the output variable is determined to create a predictive model by which the value of the selected internal composition characteristic for a subject antler can be predicted from the values calculated for the input variables for the subject antler. As used herein and in the claims, a "predictive model" means a predictive outcome or hypothesis that is based on an inductive process requiring empirical observations; "input variables" are the empirical observations used in such a model, and the "output variable" is the predictive value or hypothesized value. The output variable is then tested empirically against actual or direct measures of outcome. For example, the predicted ash content is compared for accuracy against a correlation value. Any of a number of known statistical techniques can be used to determine the relationship between the input variables and the output variable to arrive at a predictive model. These techniques include, without limitation, multiple linear regression, cluster analysis, discriminant analysis, and Artificial Neural Network learning. In many statistical techniques, the input variables are known as the independent variables, and the output variable is known as the dependent variable.

Once a predictive model for a particular antler internal composition characteristic has

been determined, a value for that internal composition characteristic can be predicted for other antlers and/or animals for which the sample population used to build the predictive model is representative. For each subject antler and/or animal, values are determined for each of the input variables in the predictive model. Depending on the predictive model used, these values may be determined from the attached antler prior to removal, from the antler after removal, or both. Values for input variables not representing temperature information, (e.g. animal weight, species type, etc.), can be obtained by the appropriate known measurement technique. Thermographic images are obtained of the antler from each view required to provide temperature information for the predictive model to be used and are stored in digitized form. Using commercially available statistics software, the appropriate statistical measures are determined for the temperature data provided by each image to provide a value for each input variable in the predictive model. The value of each input variable for the subject antler is substituted into the predictive model which has been programmed into known computing and storage means, and the predictive model is solved to provide a prediction of the measure of the antler internal composition characteristic of interest for the subject antler. Known output means can be used to provide an output of the value of the antler internal composition characteristic of interest in a form suitable for the nature of the commercial application.

Infrared thermographs can be captured using conventional infrared thermography equipment and available computer software. The view of the animal antlers can be the dorsal (top) or other views such as the lateral (side), distal (rear), ventral (bottom) or proximal (front). Alternatively, representative subsections of antler can also be used. These images can be captured prior to antler harvest non-invasively and in a manner that is unobvious to the animal such as at water or feed stations.

An example of a prediction model with additional weighting factors for non-temperature variables is as follows:

$$Y = B0 + B1X1 + B2X2 + B3X3 + B4X4 + B5X5 + B6X6$$

wherein:

Y = antler index or score

B0-B6 are coefficients: and

X1 = average IRT temp of antler, X2 = IRT temp of specific antler section, X3 = body weight of animal, X4 = antler weight, X5 = deer species, X6 = an antler anatomical feature

Again, any number of different input variables are possible for use in such a predictive model and the analysis of such data can also be possible using a variety of statistical techniques including, but not limited to, regression, cluster analysis, discriminant analysis, artificial neural networks and so forth. Once a predictive model is established, input infrared thermographs data from unknown animals can be fit to the model and a predicted maturity or composition measurement established.

BRIEF DESCRIPTION OF THE TABLE AND FIGURES

Table 1: Means and Standard Deviations for antler infrared temperatures in Wapiti stags displaying velvet antler, for Example 1.

Figure 1: Real time colour image of a stag displaying velvet antler.

Figure 2: Live antler infrared (gray tone) image of a stag (animal # 165) displaying mature velvet antler.

Figure 3: Live antler infrared (colour scale) image of a stag (animal # 165) displaying mature velvet antler.

Figure 4: Live antler infrared (gray tone) image of a stag (animal # 66) displaying an immature velvet antler.

Figure 5: Live antler infrared (colour) image of a stag (animal # 66) displaying an immature velvet antler.

Figure 6: Frozen antler real time image of a mature velvet antler (animal # 165).

Figure 7: Frozen antler real time image of an immature velvet antler (animal # 66).

Figure 8: Frozen antler infrared image (gray tone) of an immature (left, animal # 66) and mature (right, animal # 165) time 0 after removal from the freezer.

Figure 9: Frozen antler infrared image (gray tone) if an immature (left, animal # 66) and mature (animal # 165) time 2.45h after removal from the freezer.

Figure 10: Frozen antler infrared image (gray tone) of an immature (left, animal # 66) and mature (right, animal # 165) time 5.50 h after removal from the freezer.

Figure 11: Frozen antler infrared image (colour) of an immature (left, animal # 66) and mature (right, animal # 165) time 0h after removal from the freezer.

Figure 12: Frozen antler infrared image (colour) of an immature (left, animal # 66) and mature (right, animal # 165) time 2.25h after removal from the freezer.

Figure 13: Frozen antler infrared image (colour) of an immature (left, animal # 66) and mature (right, animal # 165) time 5.50h after removal from the freezer.

Figure 14: Schematic diagram of antler example (animal # 165) showing where sections of antler were taken for the *in vitro* ash analysis (Table 3 of Example 1).

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The infrared thermography equipment used in the present invention is known in the art. For example, an Inframetrics 760 broadband camera (Inframetrics Comp. North Billercia, MA) fitted with a 0.5 X lens was used by the inventors in the study described in the example. Other suitable lenses can be used. Thermogram image software (Inframetrics Inc. North Bellercia) and View Scan Software (View Scan Ltd. Concord, Ont.) was utilized, however, other suitable software can be employed.

For *in vivo* thermographs, the animals and antlers are preferably scanned from about 1 to 3 meters away and the images should be obtained from unstressed animals. Infrared thermographic scans are collected from a variety of views including dorsal (top), distal (rear), lateral (side) and proximal (front). In the inventors experience, the scans showing the greatest utility are the dorsal, proximal and lateral scans.

The image area and selected image temperature statistics are calculated for each image. The number of pixel counts per image may vary depending on the camera, degree of resolution, size of image and so forth. A typical pixel field is 135 X 256. Each pixel has a thermographic value assigned which corresponds to an actual temperature value. Actual temperature values can be calculated for example from the following formula:

$$\textit{Actual Temperature} = \frac{\text{max } \textit{temp setting} - \text{ min } \textit{temp setting}}{256} \; x \; \textit{pixel value}$$

Pixel colours can be used instead of gray tones in the analysis or presentation of data such as in the accompanying Figures.

For a predictive model, statistical calculations from the data such as image mean temperature, standard deviation, mode and so forth are input variables. As stated earlier, other input variables representing animal or antler properties can also be used. Such predictive values can be expressed as proportions of an antler grade or classification value based on composition.

For *in vitro* thermographs collected from thawed antler sections the images are

collected using the equipment and software as described above. Since materials of different density and heat capacities are known to heat or cool at different rates it is reasonable that antler tissue differing in density or ash composition also displays differential infrared thermographic heat characteristics *in vitro*. Continuous data tape collection of data was possible, however, analysis as presented is for times 0 hour, 2.45 hours and 5 hours post removal from the freezer. Antler from animal #165, as shown in figures 8 to 13, was removed from a -20C freezer and placed at room temperature(20C). A circulating fan was used to maintain a constant temperature over the entire antler. The differential rate of antler section thawing was recorded. The thermographic scan changes were seen to display different rates (slope) of heating suggesting that the assessment or classification of the antler could also be conducted on thawing, or cooling, antler tissue in vitro.

For *in vitro* thermographs, or thermographs collected from cooling or thawed antler sections, the images can be collected using the same equipment and software as described above, or with suitable alternatives.

EXAMPLES

Example 1

In the present invention, the inventors studied infrared thermographic scans to differentiate antler of differing maturity.

Considerable variation in velvet antler maturity and composition is evident in animals across the industry. This is one of the factors that makes estimating times for harvesting antlers at optimal or preferred composition difficult. As shown in Table 1, considerable variation is evident in the infrared thermographic expression both within and among antlers. Figures 2 - 13 further display this variation in thermal characteristics and further illustrate that for the most metabolically active tissue an increased temperature on live tissue or heating slope on thawing tissue is evident whether measured in the live tissue or in the thawing antler. Also, the most metabolically active tissue is also seen to display the lowest ash content, as seen in Tables 2 and 3.

For this example, both infrared thermographic and ash composite analysis were completed on velvet antler from one stag known to be displaying a mature rack of velvet antler (Animal # 165). This animal was monitored in June of 1998 and was from a domestic herd of wapiti stags in central Alberta. The data collected on this animal was completed by staff from

Lacombe Research Center of Agriculture and Agri-Food Canada and Public Works Canada, Edmonton. To facilitate data collection the animal was brought from outdoor paddocks, with pen mates, into an enclosed handling facility designed specifically for wapiti. The animal and the velvet antler were scanned while unrestrained soon after arrival into the facility. A 760 Inframetrics broad band infrared camera as described earlier was used to scan the animal at a distance of approximately 3 meters. The animal was subsequently restrained in a holding facility and the velvet antler removed using conventional methods common in the industry. The removed antler was subsequently frozen and then scanned after later removal from the freezer and thawing (Figures 2 - 13). For compositional analysis, selective slices of 0.5 cm thickness were sectioned from a specific antler (animal # 165), (Figure 14), and were taken for chemical ash analysis (Tables 2 and 3). These sections were dried to constant weight and subsequently analyzed for ash content using conventional procedures (AOAC 1995). In short, the antler sections were placed in a muffle oven held at approximately 550°C for 40 h and the samples then measured gravimetrically. The following information was collected on the antler: live infrared thermographic temperature profile, infrared thermographic profile from the thawing antler at different times post removal from the freezer, and ash analysis of the antler from selective anatomical sites. Interestingly, the correlation coefficient between the *in vivo* and/or *in vitro* antler temperature profile collected from the identified sites, (Figure 14), and the ash composition was apparent, suggesting a close or high degree of relationship between infrared thermographic profile and objective antler composition.

Table 2: Antler section % moisture and % ash for in-vitro analysis (animal # 165)

Antler Site	% Moisture	% Ash
1	47.6	24.0
2	55.1	17.9
3	65.6	9.2
4	51.0	21.1
5	50.4	21.9
6	63.1	11.0
7	53.4	18.9
8	62.1	12.0
9	63.1	12.0
10	81.1	1.4

Table 3: Antler section % moisture, % ash, live antler temperature (°C) and heat slope from animal # 165

Antler Site	% Moisture	% Ash	Live Antler Temp	Heat Slope 1
1	47.6	24.0	29.2	(a) 4.4
				(b) 2.4
				(c) mean 3.4
8	62.1	12.0	29.9	(a) 4.9
				(b) 1.2
				(c) mean 3.0
10	81.1	1.4	31.0	(a) 4.6
				(b) 2.0
				(c) mean 3.3

1 heat slope = change in infrared temperature / change in time post removal from freezer.
(a) = time 0 – 2.45h, (b) = time 2.45 - 5.00 h

Example 2

Antlers were scanned *in vivo* and subsequently scanned after harvest to record the Infrared thermographic images as the antler cooled. Subsequent analysis of the images provided a correlation between the antler maturity and calcification and the infrared

thermographic cooling images. Thus, images taken on post harvest antler within a reasonable period after harvest, can be used to predict antler maturity and/or ash content.

Antlers were analyzed on cooling to room temperature over the first hour after removal from the animal.

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Table 1

Temperature (°C) of 26 velvetted antlers (Left side and Right side)

Animal #	Position	Pixels	Min	Max	Average	S.D.
52	right	1515	23.53	34.68	30.38	1.83
52	left	1428	21.42	35.59	30.22	2.81
91	right	3233	26	35.9	32.74	1.21
91	left	3641	22.5	36.6	32.77	1.43
90	right	3645	24.77	35.92	32.66	1.36
90	left	3700	23.48	37.21	32.76	1.05
8	right	2954	26.5	36.7	32.66	1.34
8	left	2821	25.6	35.4	32.17	1.28
88	right	1967	22.42	36.89	30.09	1.81
88	left	1782	24.63	34.48	30.38	1.78
85	right	3309	16.39	37.9	29.63	3.14
85	left	2882	17.29	37.4	29.3	3.04
78	right	4465	20.48	34.74	29.35	1.77
78	left	4049	23.55	34.54	29.44	1.68
72	right	2695	23.17	34.22	28.16	2.05
72	left	3162	19.99	35.81	28.71	2.58
71	right	2238	26.46	35.21	31.87	1.76
7	left	2246	24.07	34.62	31.5	1.3
70	right	2297	22.52	35.54	28.93	1.66
70	left	2722	22	36.06	28.52	2.02
69	right	3448	22.33	35.46	30.92	1.54
69	left	3503	23.54	35.96	30.38	1.74
67	right	2439	20.91	36.29	30.68	2.17
67	left	2686	23.83	35.59	30.53	1.69
66	right	1666	23.6	34.97	30.42	1.64
66	left	1507	22.08	34.36	29.98	1.51
64	right	1772	23.86	35.47	29.68	1.98
64	left	1919	21.43	34.67	29.81	1.77
63	right	1559	22.6	34.8	29.39	1.8
63	left	1412	24.4	33.2	29.29	1.7
59	right	1796	21.4	35	29.9	2.04
59	left	1870	20.4	34.4	30.08	2.08
54	right	1835	22.43	35.29	29.64	1.68
54	left	1749	23.93	35.09	29.53	1.62
53	right	1652	23.31	33.86	29.64	1.66
53	left	1934	20.46	33.66	28.69	1.74
52	right	1670	21.76	34.65	30.26	1.84
52	left	1454	27.67	35.56	30.04	2.83
43	right	2645	19.6	36.67	32.08	2.03
43	left	3513	24.45	37.58	32.54	1.8
38	right	3293	22.2	33.5	28.42	1.54
38	left	2712	21.6	35.5	28.75	2.1
24	right	3742	25.6	36.4	33.06	1.53
24	left	3688	27.1	36.2	33.13	1.32
20	right	3924	19.69	35.42	28.96	2.32
20	left	3968	23.38	36.31	29.53	2.1
165	right	3025	18.79	35.16	29.72	2.89
165	left	2915	23.14	34.45	30.37	1.69
131	right	2816	21.94	35.13	29.06	1.56

	131 left	2970	21.53	34.53	29.64	1.56
	103 right	2324	22.44	35.68	30.68	1.7
	103 left	2179	21.13	34.97	29.48	1.67
Mean		**2622**	**22.68**	**35.41**	**30.32**	**1.84**
Range	**right**	**16.9**	**37.9**			
(°C)	**left**	**17.29**	**37.58**			
		16.9	**37.9**			

Range within Antlers (- 2.78 °C to + 1.88 °C or 4.66 °C) FROM MEAN

These numbers include two animals who display calcification: # 85 and 165

Temperature (°C) of 26 velvetted antlers (Left side + right side)

Animal #	Pixels	Max	Min	Average	S.D.	range within antlers
52	1471.5	22.475	35.135	30.3	2.32	0.02
91	3437	24.25	36.25	32.755	1.32	-2.44
90	3672.5	24.125	36.565	32.71	1.205	-2.39
8	2887.5	26.05	36.05	32.415	1.31	-2.10
88	1874.5	23.525	35.685	30.235	1.795	0.08
85	3095.5	16.84	37.65	29.465	3.09	0.85
78	4257	22.015	34.64	29.395	1.725	0.92
72	2928.5	21.58	35.015	28.435	2.315	1.88
71	2242	25.265	34.915	31.685	1.53	-1.37
70	2509.5	22.26	35.8	28.725	1.84	1.59
69	3475.5	22.935	35.71	30.65	1.64	-0.33
67	2562.5	22.37	35.94	30.605	1.93	-0.29
66	1586.5	22.84	34.665	30.2	1.575	0.12
64	1845.5	22.645	35.07	29.745	1.875	0.57
63	1485.5	23.5	34	29.34	1.75	0.98
59	1833	20.9	34.7	29.99	2.06	0.33
54	1792	23.18	35.19	29.585	1.65	0.73
53	1793	21.885	33.76	29.165	1.7	1.15
52	1562	24.715	35.105	30.15	2.335	0.17
43	3079	22.025	37.125	32.31	1.915	-1.99
38	3002.5	21.9	34.5	28.585	1.82	1.73
24	3715	26.35	36.3	33.095	1.425	-2.78
20	3946	21.535	35.865	29.245	2.21	1.07
165	2970	20.965	34.805	30.045	2.29	0.27
131	2893	21.735	34.83	29.35	1.56	0.97

103	2251.5	21.785	35.325	30.08	1.685	0.24
	2622	**22.68**	**35.41**	**30.32**	**1.84**	

WHAT IS CLAIMED IS:

1. A method for evaluating the internal composition of a velvet antler, comprising the steps of:

obtaining at least one infrared thermographic image of said velvet antler, from at least one view, wherein said obtained thermographic image is capable of being represented as an array of pixels providing temperature data representative of temperature information at the corresponding part of the image;

calculating the value of at least one statistical measure of the temperature data for each thermographic image;

providing a predictive model wherein said internal composition characteristic is included as an output variable, and said at least one statistical measures of temperature data for each thermographic image are included as input variables; and

solving said predictive model to provide a measure of a velvet antler internal composition characteristic.

2. The method of claim 1, wherein:

the at least one infrared thermographic image is taken of one or more velvet antlers *in vivo*.

3. The method of claim 1, wherein the predictive model output variable is used to provide a map of each antler indicating areas of statistically higher and lower levels of said internal composition characteristic.

4. The method of claim 1, comprising the further step of:

obtaining the value of at least one property of said velvet antler, *in vivo* or *in vitro*, that does not provide temperature information, and wherein said property is included as an input variable in said predictive model.

5. The method of claim 4, wherein the property that does not provide temperature information is a geometric measure of the antler.

6. The method of claim 5, further comprising the steps of:

using said predictive model to solve the physical volume of said areas of low temperature; solve the physical volume of said antler; and calculate the percentage by volume of the antler with the low temperature indication.

7. The method of claim 6, further comprising the step of:

solving a further predictive model with a percentage by volume as an input variable and an expected ash composition of the velvet antler as an output variable.

8. The method of claim 7, further comprising the step of:

comparing said expected ash composition with a pre-determined maximum desired ash composition, to determine the optimum harvest date of the velvet antler.

9. The method of claim 1, wherein the at least one statistical measure of temperature is selected from the group consisting of measures of central tendency, measures of dispersion, and measures of total temperature.

10. The method of claim 1, wherein the thermographic images comprise an image the antler *in vivo* and or *in vitro*, and said statistical measure comprises the mean temperature.

11. The method claim 1, wherein said velvet antlers are antlers grown on animals in the species cervidae, (cervus elaphus manitobensis, cervus elaphus nelsoni, cervus elaphus roosovelti, cervus elaphus scoticus, cervus elaphus xanthopygus, cervus sika, and cervus unicolor), and alces alces, rangifer tarandus, dama dama, odocoileus virginianus, and rusa timorensis.

12. The method of claim 1, wherein the measure of said antler internal composition characteristic is the location and amount of calcification within the antler.

13. The method of claim 1, wherein the internal composition characteristic output variable is percent ash.

14. The method of claim 12, further comprising the step of using the internal composition characteristic output variable to determine optimal harvest timing, based on pre-determined values.

15. The method of claim 1, wherein:

the at least one infrared thermographic image is taken of one or more antlers *in vitro*, from one or more views, within a reasonable period after the antler is removed from the animal.

16. The method of claim 15, further comprising the steps of:

obtaining at least one infrared thermographic image of the antler from the same view(s), at a time period statistically later than the first image;

analyzing the images to calculating a measure of temperature changes at points within the antler; and

using said temperature change data to predict areas of high calcification and low metabolic activity.

17. The method of claim 1, wherein the at least one infrared thermographic image is taken of one or more antlers *in vitro*, after the antlers are frozen and comprising the additional steps of:

taking a second image after the antler has been allowed to warm for a statistically significant time period;

analyzing the images to calculate data indicating temperature change at points within the antler;

inputting the temperature change data into the predictive model; and

solving said predictive model to provide a measure of a velvet antler internal composition characteristic.

18. A method for evaluating the internal composition of a velvet antler, comprising the steps of:

obtaining at least one infrared thermographic image of said velvet antler, from at least one view, wherein said obtained thermographic image is capable of being represented as an array of pixels providing temperature data representative of temperature information at the corresponding part of the image;

calculating the statistical value of an antler mean temperature for each thermographic image; and

using the antler mean temperature value and the image temperature data to provide a map of each antler indicating areas of statistically higher and lower temperatures than the antler mean temperature range established for the species scanned.

19. The method of claim 18, wherein:

areas of said map identified as statistically lower temperatures are further identified as areas likely to have internal compositions with low metabolic activity, and potentially high levels of calcification.

20. The method of claim 18, further comprising the step of:

using said map to identify areas of pre-determined specific temperatures as areas indicating specific metabolic rates and properties.

21. The method of claim 19, further comprising the step of:

using the map of the antler to identify areas of the antler to remove before processing to reduce the antler's overall percentage calcified matter content.

Figure 1

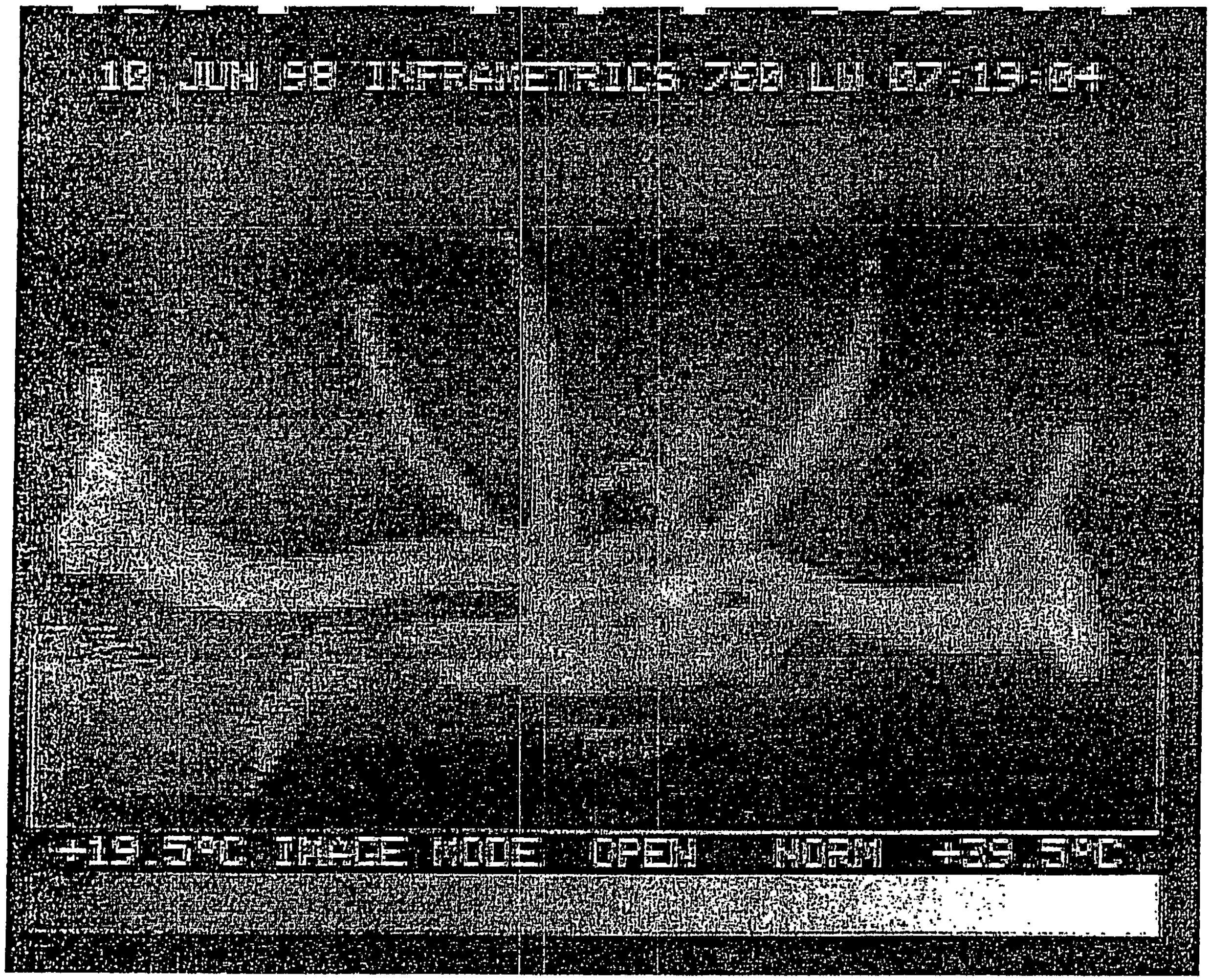
10 JUN 98 INFRAMETRICS 760 LW 07:19:04
+19.5°C IMAGE MODE OPEN NORM +39.5°C

Figure 2

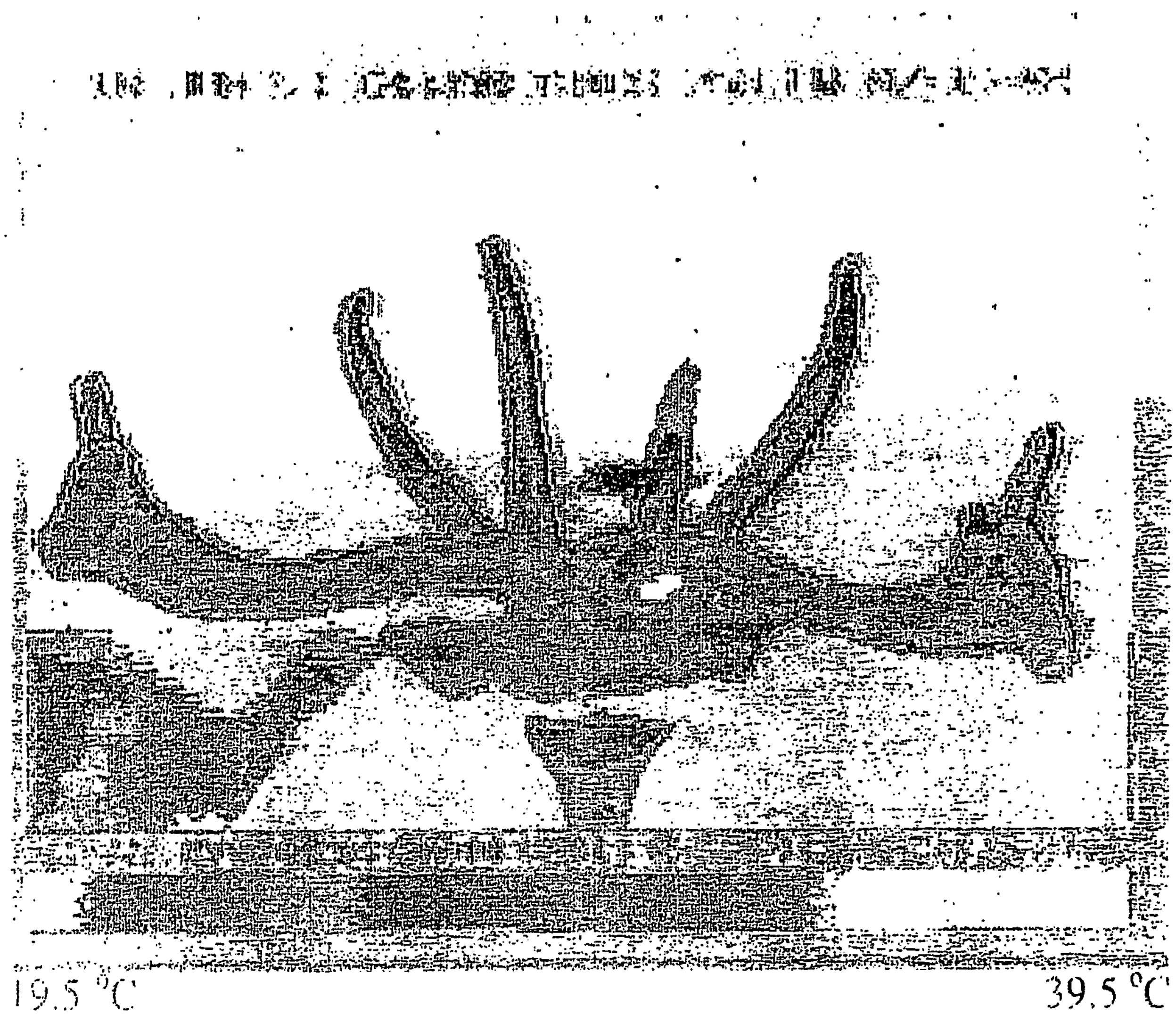

Figure 3

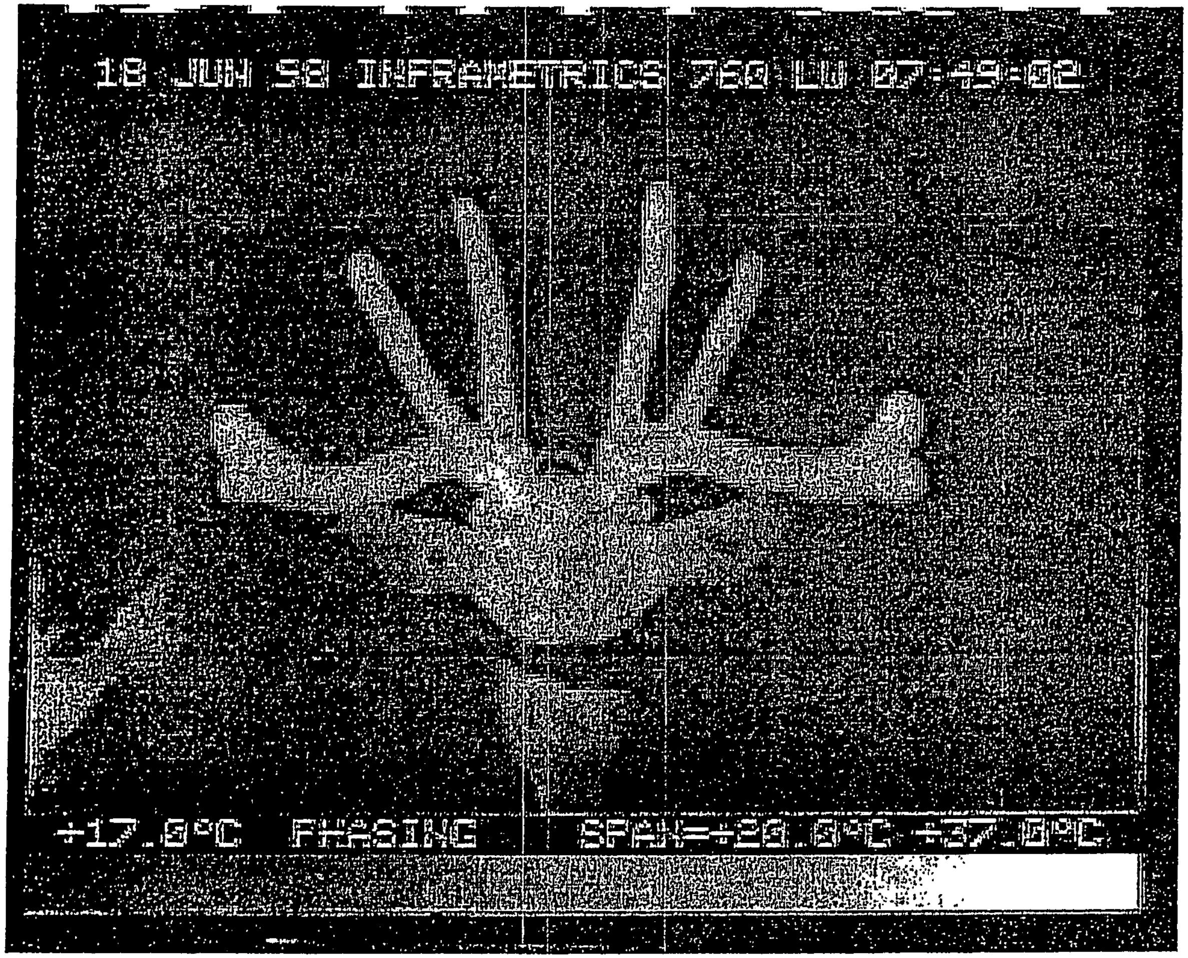
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Figure 4

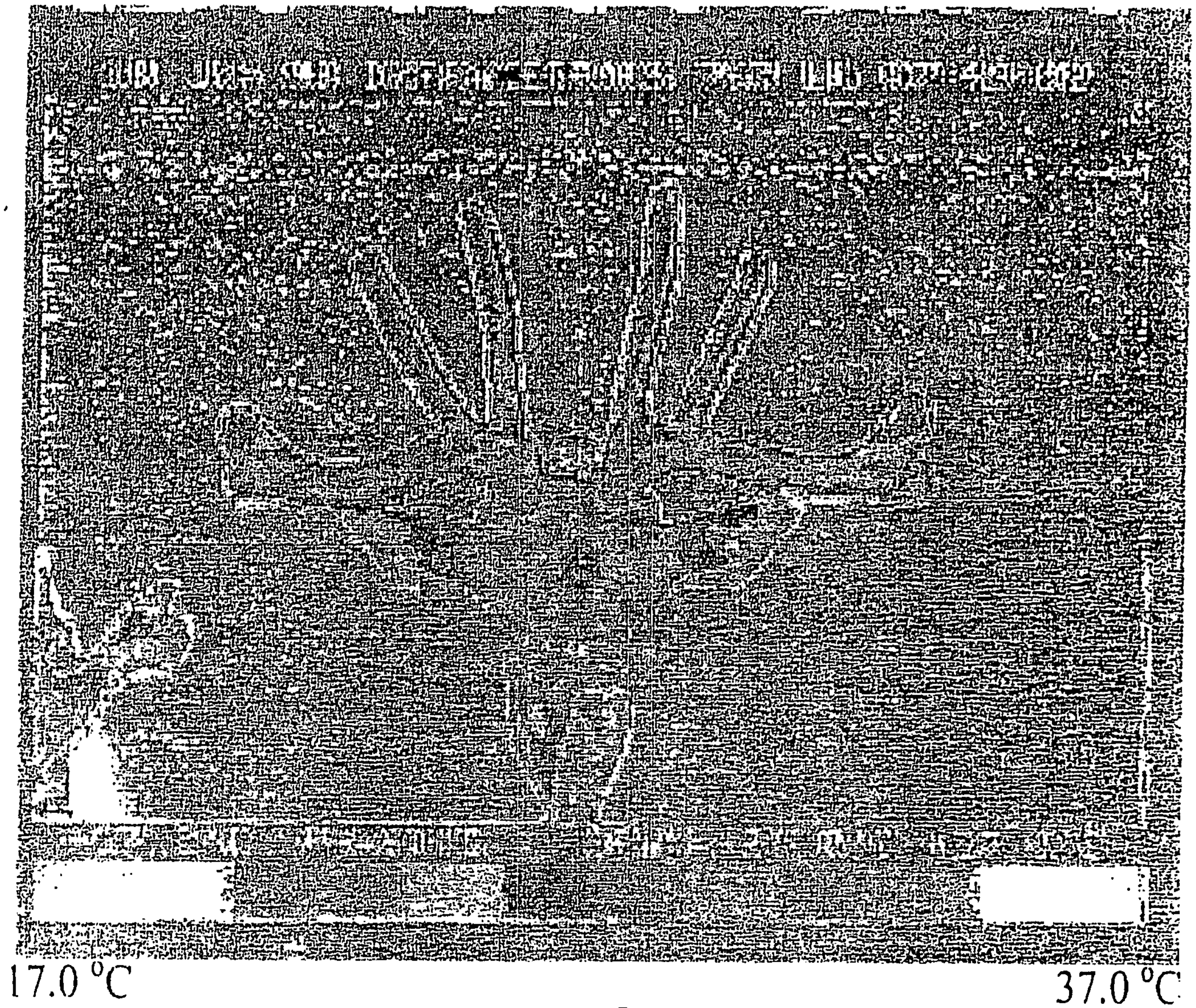


Figure 5

Figure 6

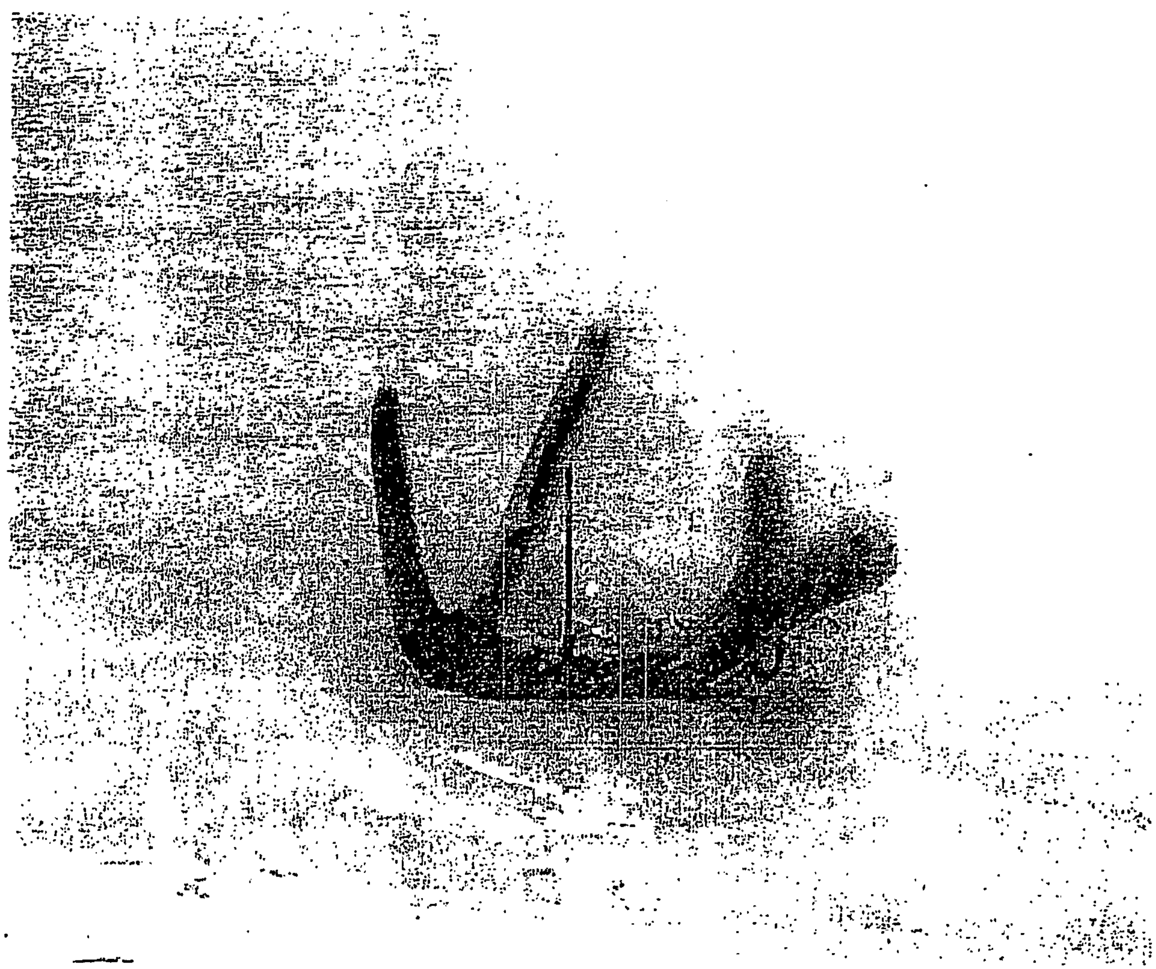
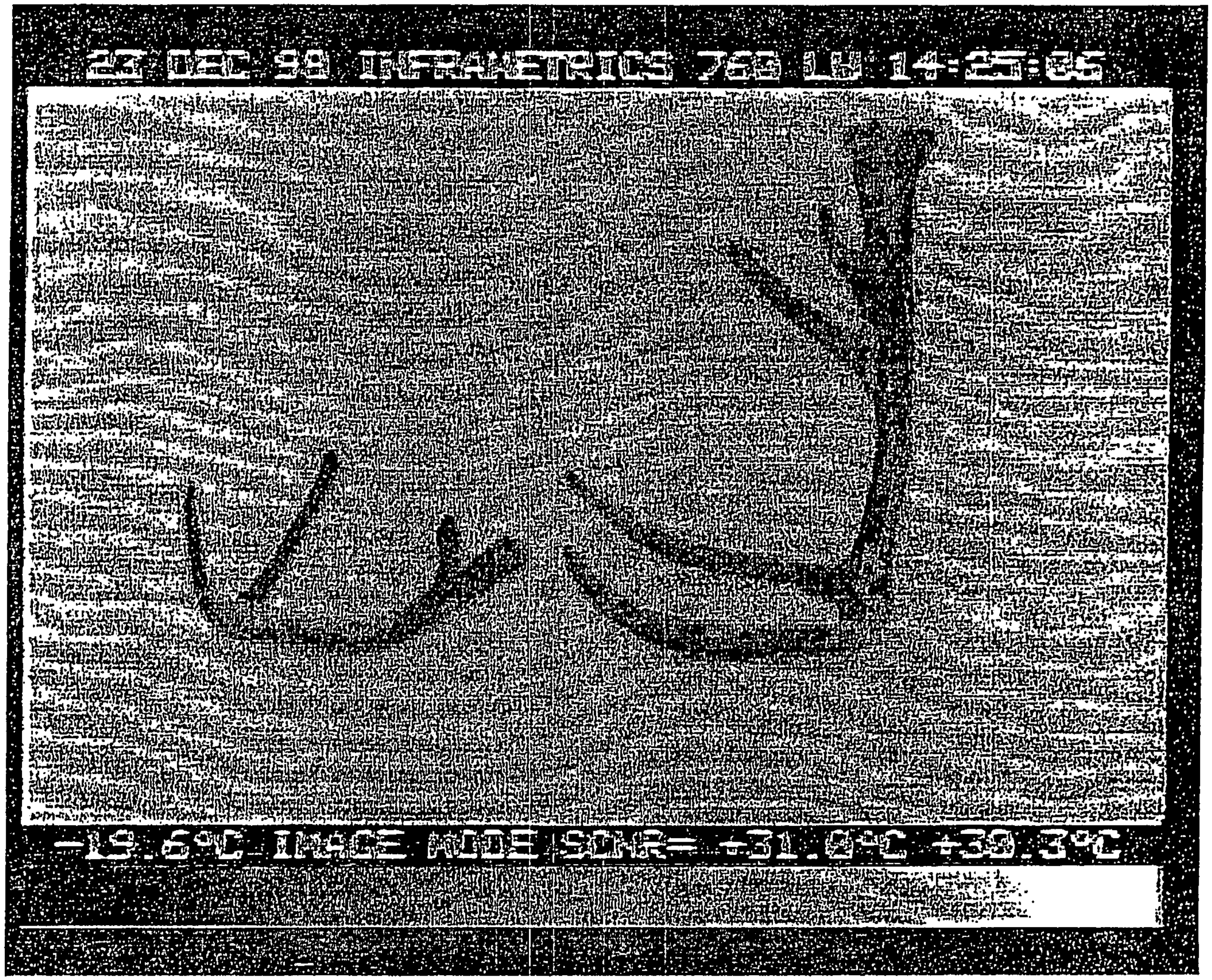
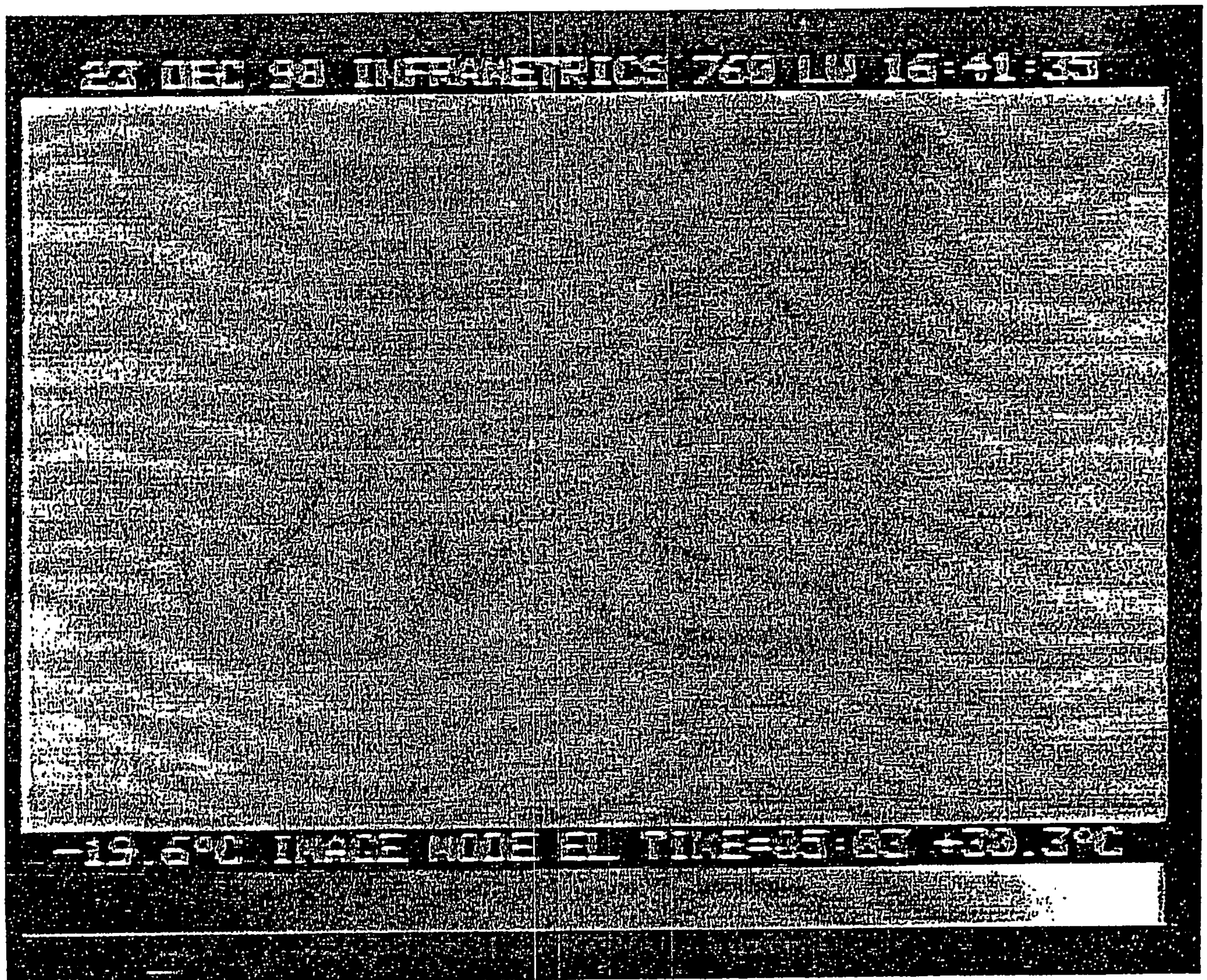


Figure 7



(Frozen Antlers time 0 h)

Figure 8

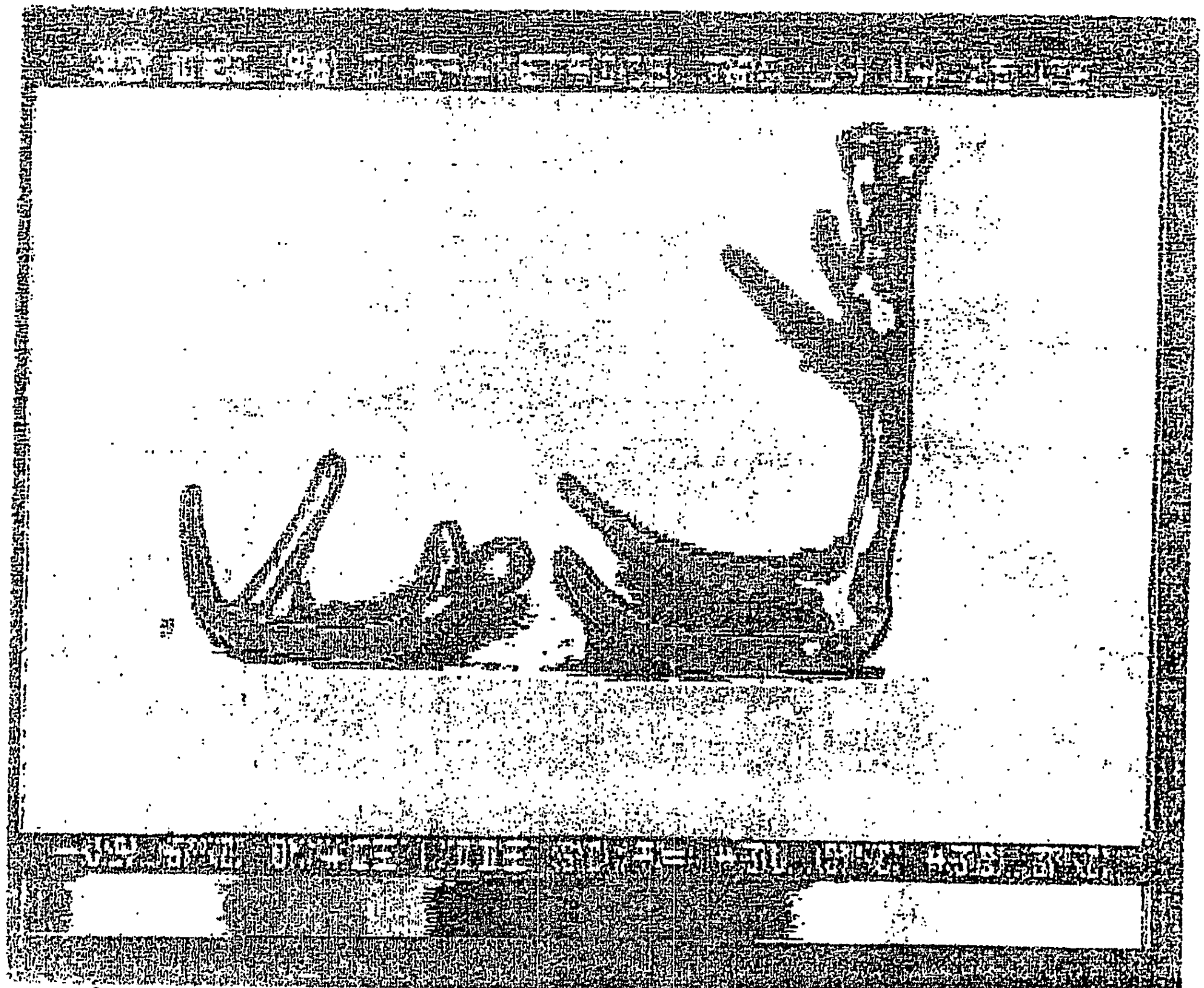


(Frozen Antlers time 2.45 h)

Figure 9

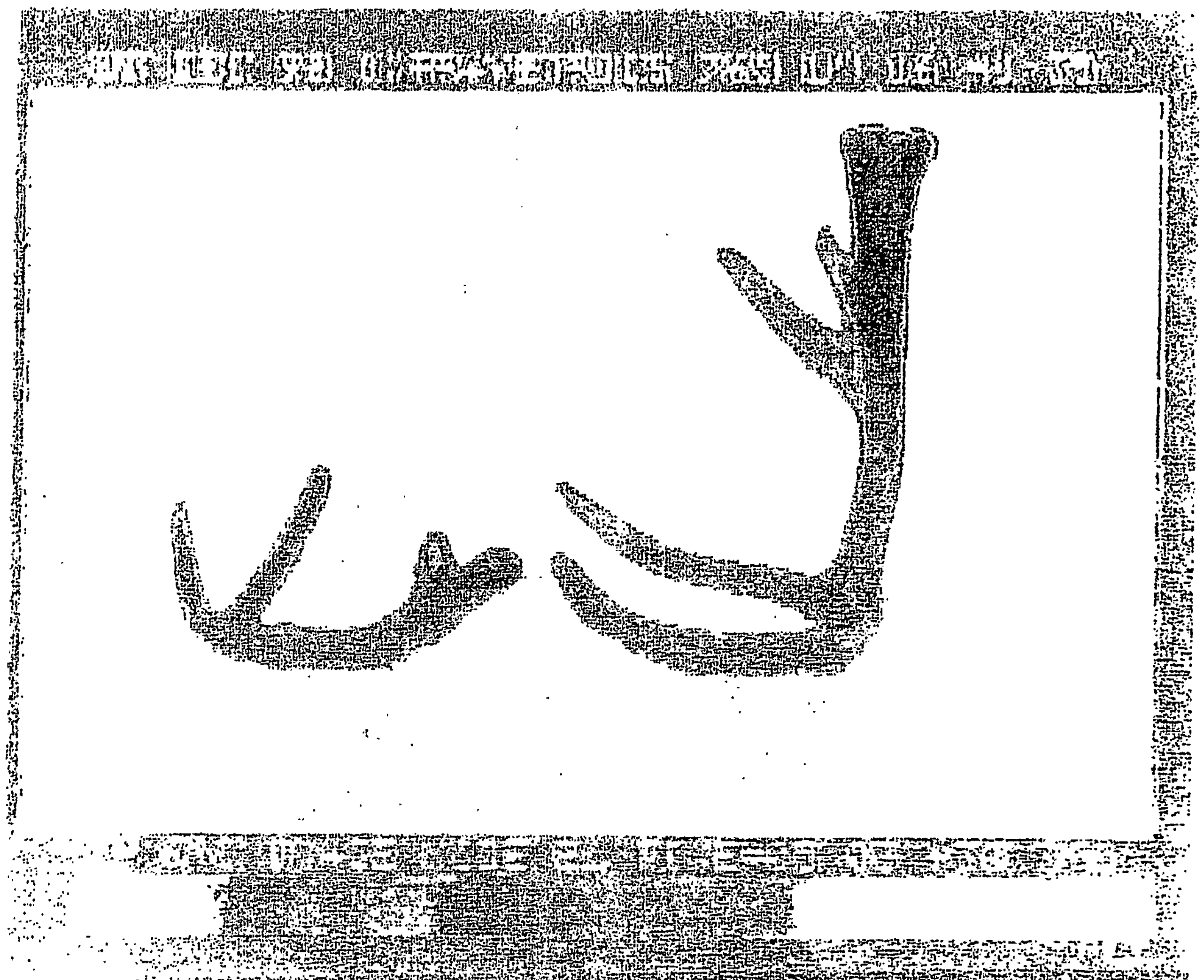

23 DEC 98 INFRAMETRICS 760 LW 19:58:24
-19.6°C IMAGE MODE IMG AVE=32 F +30.3°C

Figure 10



-19.6 °C (Frozen Antlers Time 0 h) +30.3 °C

Figure 11



-19.6 °C (Frozen Antlers Time 2:45 h) +30.3 °C

Figure 12

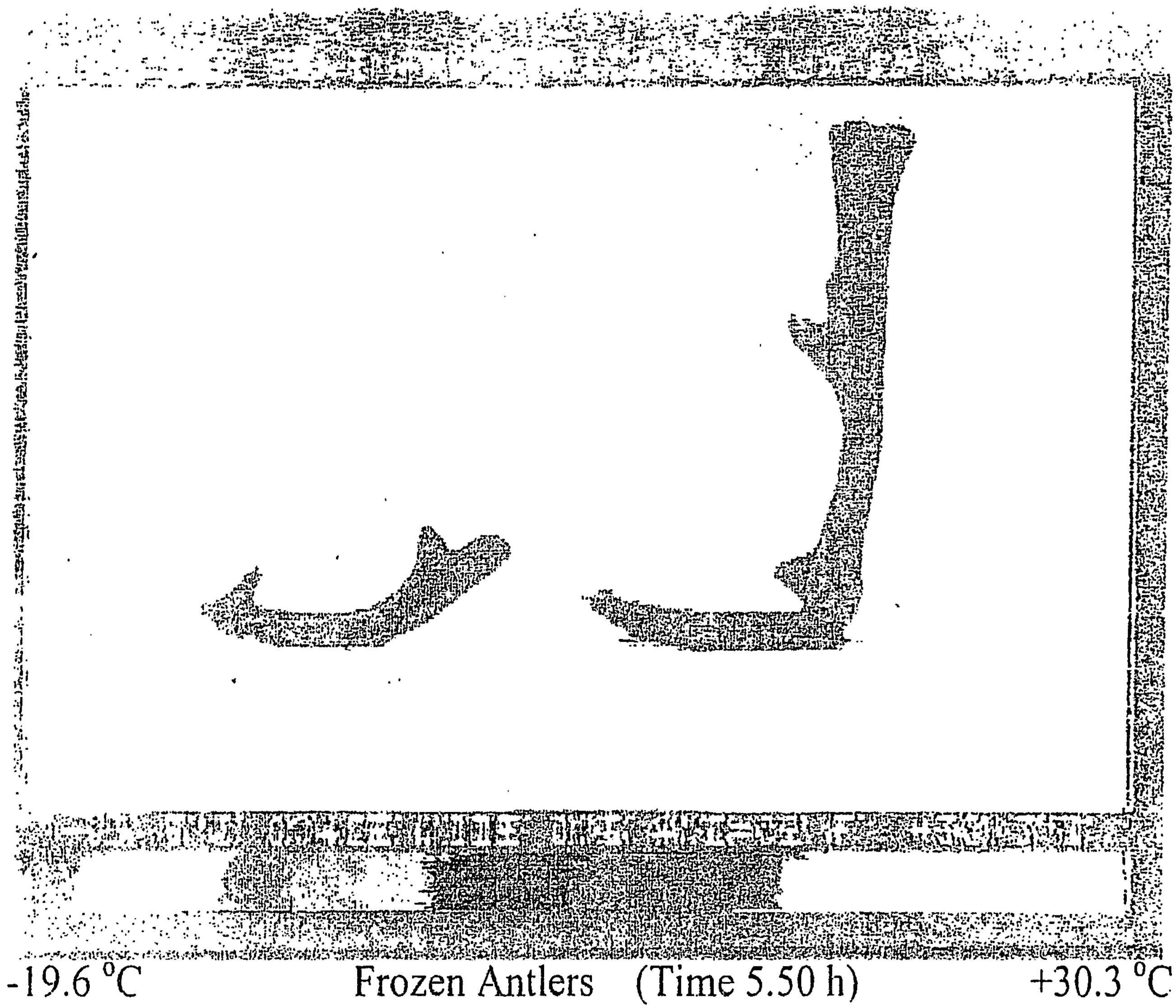


Figure 13

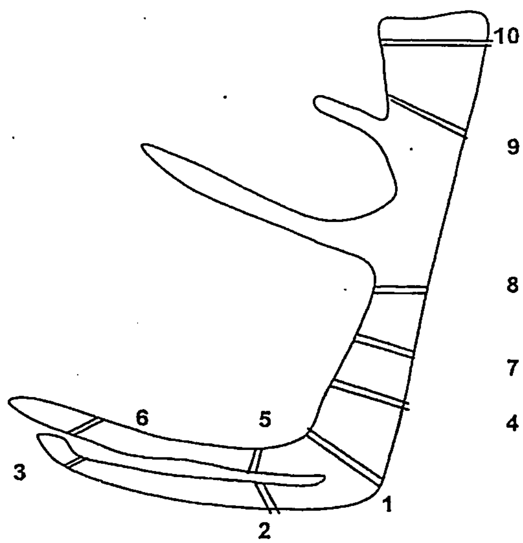


Figure 14

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